

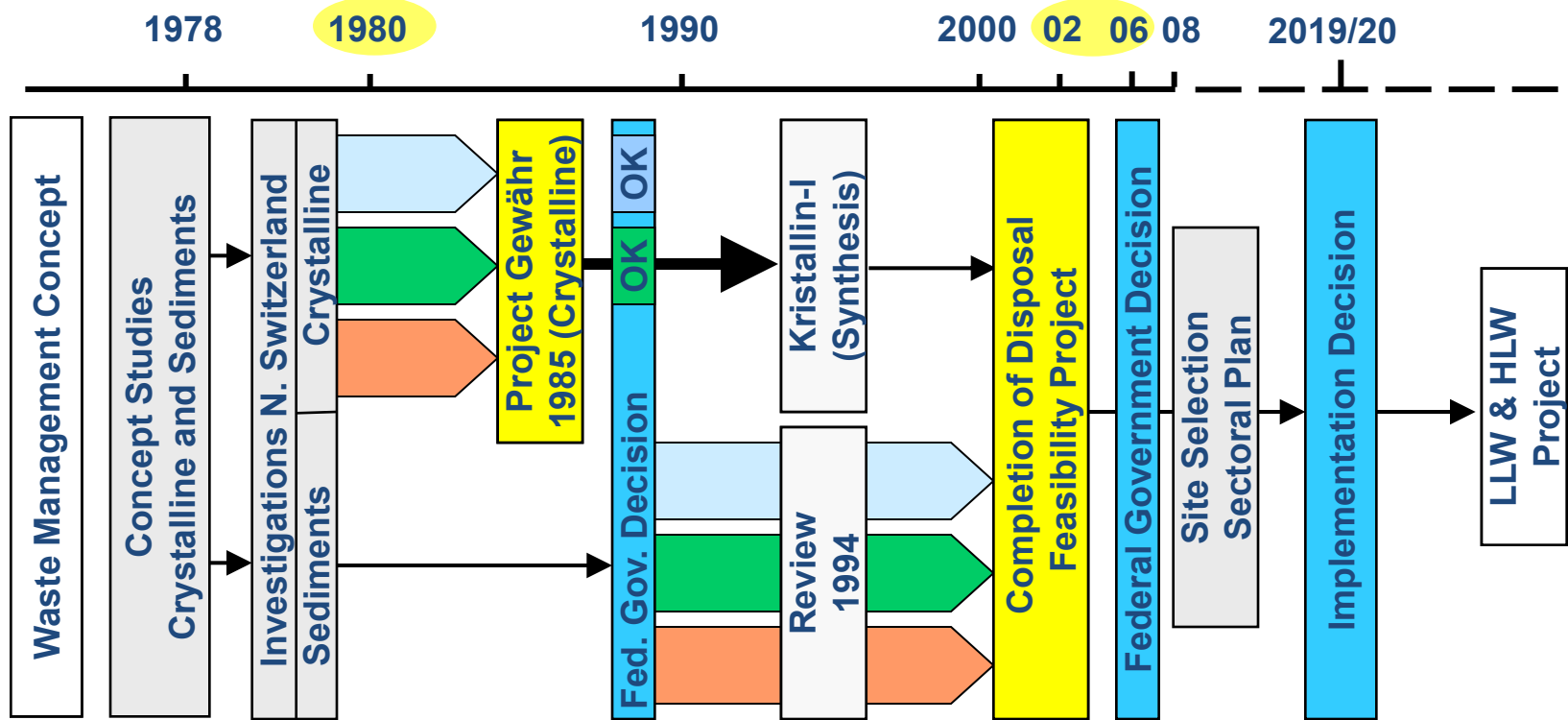
2.2.2

Siting process – Experience from the Swiss Radioactive Waste Management Programme

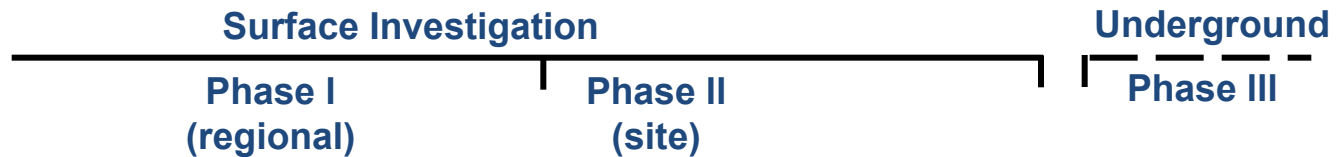
Dr. Stratis Vomvoris

nagra.

HLW geologic repository - overview



Phases of Siting Programme:



Demonstration of Disposal Feasibility

- Demonstration that a repository for spent fuel, vitrified high-level waste and long-lived intermediate-level waste of Swiss origin can be built in Switzerland (meeting all required standards, e.g. regulatory guideline HSK-R-21). It consists of three elements:
 - **Siting Feasibility:** Demonstration that a **site exists** in Switzerland where a repository can be built
 - **Construction Feasibility:** Demonstration that a repository can **be built** at a given site and **using current technology**
 - **Long-Term Safety:** Demonstration that **a given repository design** for a repository at **a given site**, meets the applicable standards for **long-term safety**



GEOSYNTHESIS

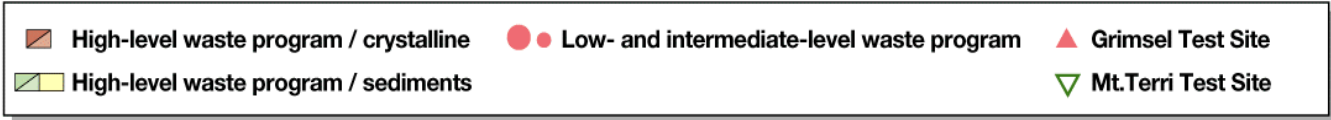
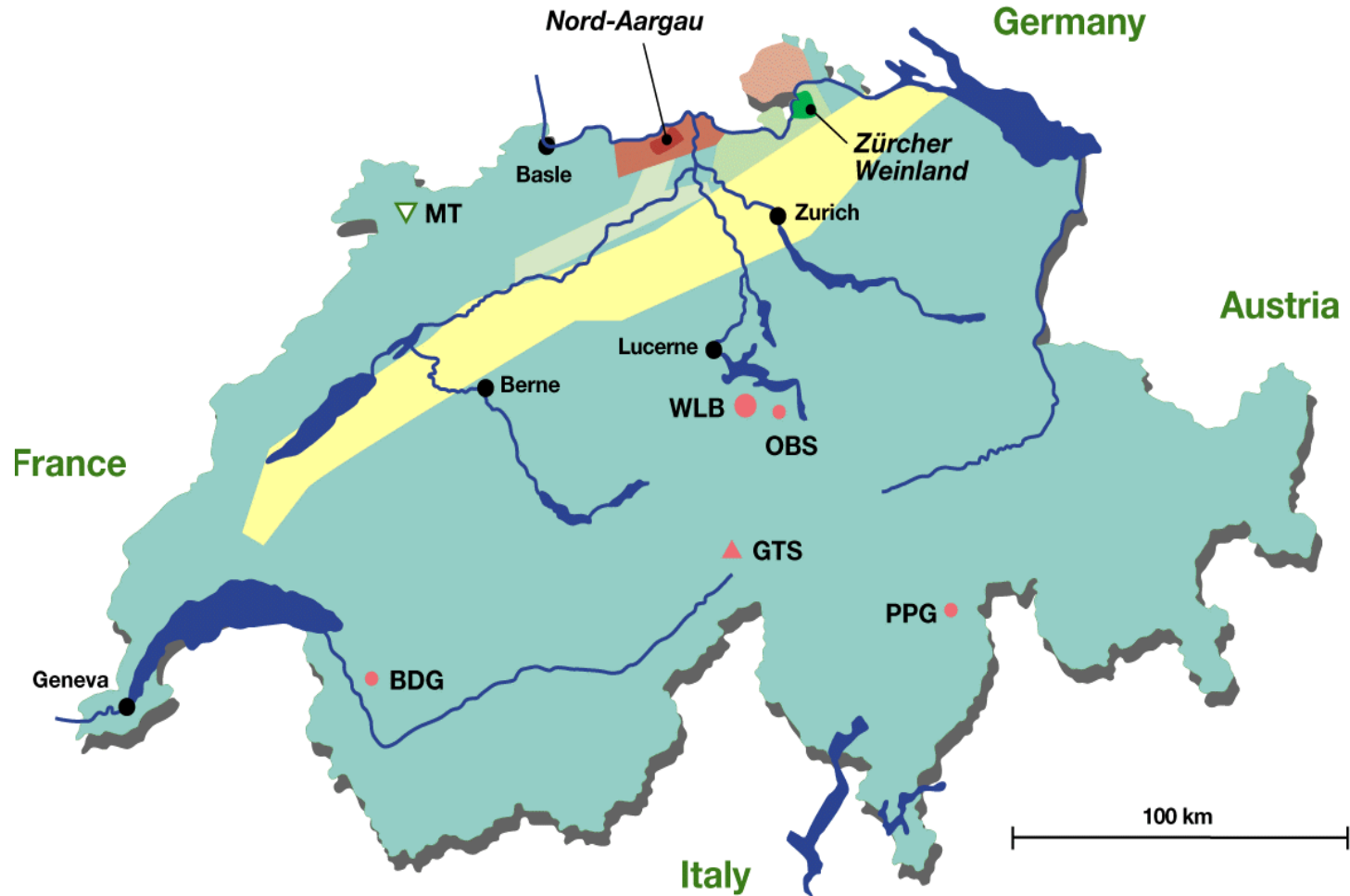


FACILITIES and
OPERATION

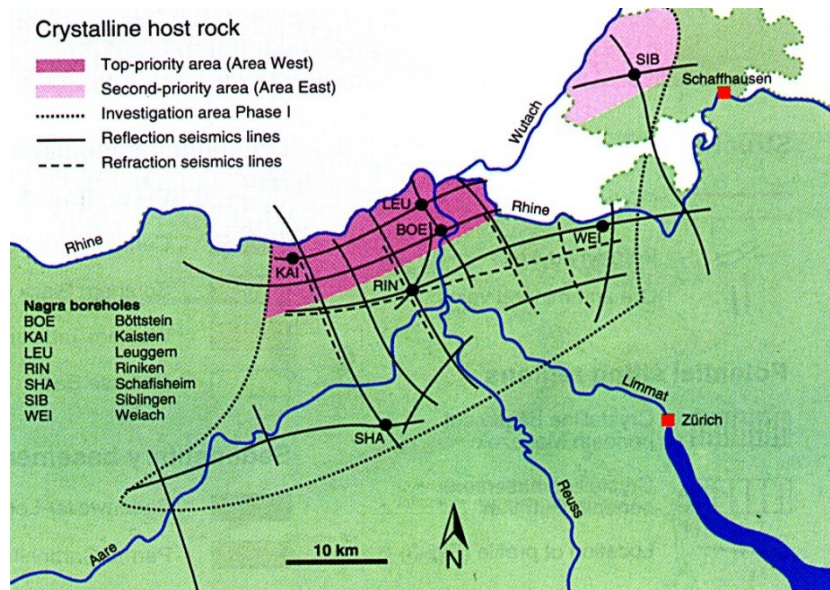


SAFETY

Nagra projects (1980 - 2006)



NAGRA's Crystalline Project (KRI): Phase 1

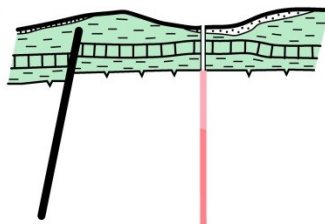


- A deep drilling campaign comprising 7 boreholes with final depths between 1306 and 2482 m.
- Geophysical investigations consisting of reflection and refraction seismic lines, gravimetric and aeromagnetic surveys, etc.
- Long-term monitoring of deep groundwaters
- Hydrogeological modelling

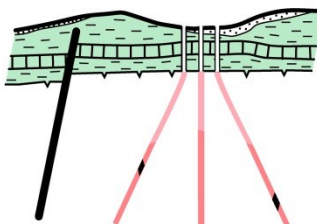
- Hydrochemical studies
- Geological mapping and data compilation
- Geological reconnaissance studies of exposed basement rock in nearby Germany
- Neotectonic studies, including a micro-earthquake recording network, geodetic measurements, geomorphological studies and stress measurements

Conclusion of Phase 1
with a proposal for
site investigations and
initiation of Phase 2

- ① Reflection seismics survey
- ② Vertical borehole



- ③ a) Four inclined boreholes (star configuration)



- ③ b) Seismic tomography
Crosshole hydro-testing



ca. 1 km

— Proposed disposal area

Legend



Sedimentary cover

Crystalline basement



Higher-permeability domain



Low-permeability domain



Major water-conducting fault

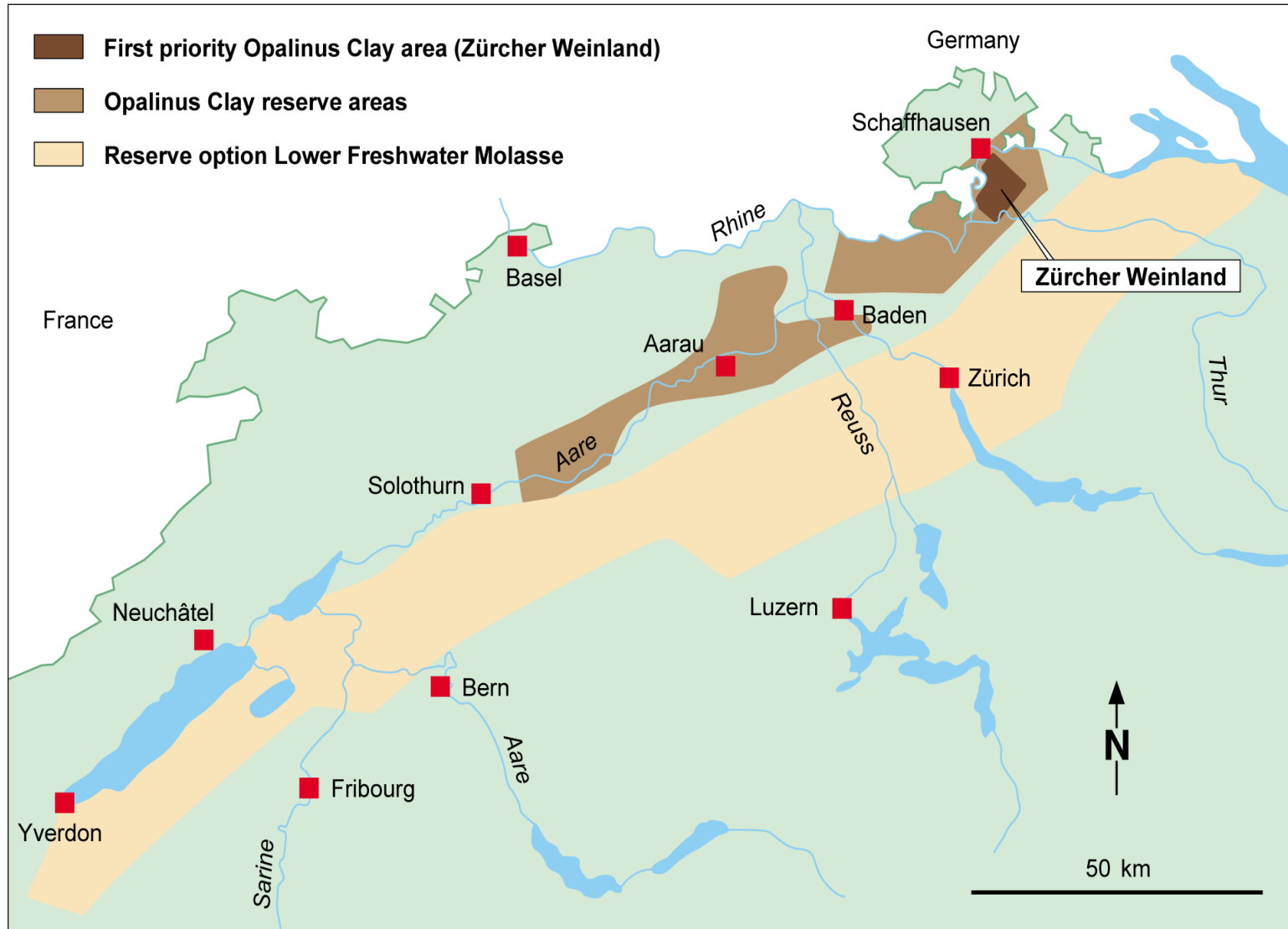


Boreholes



Shaft

Options in sedimentary formations

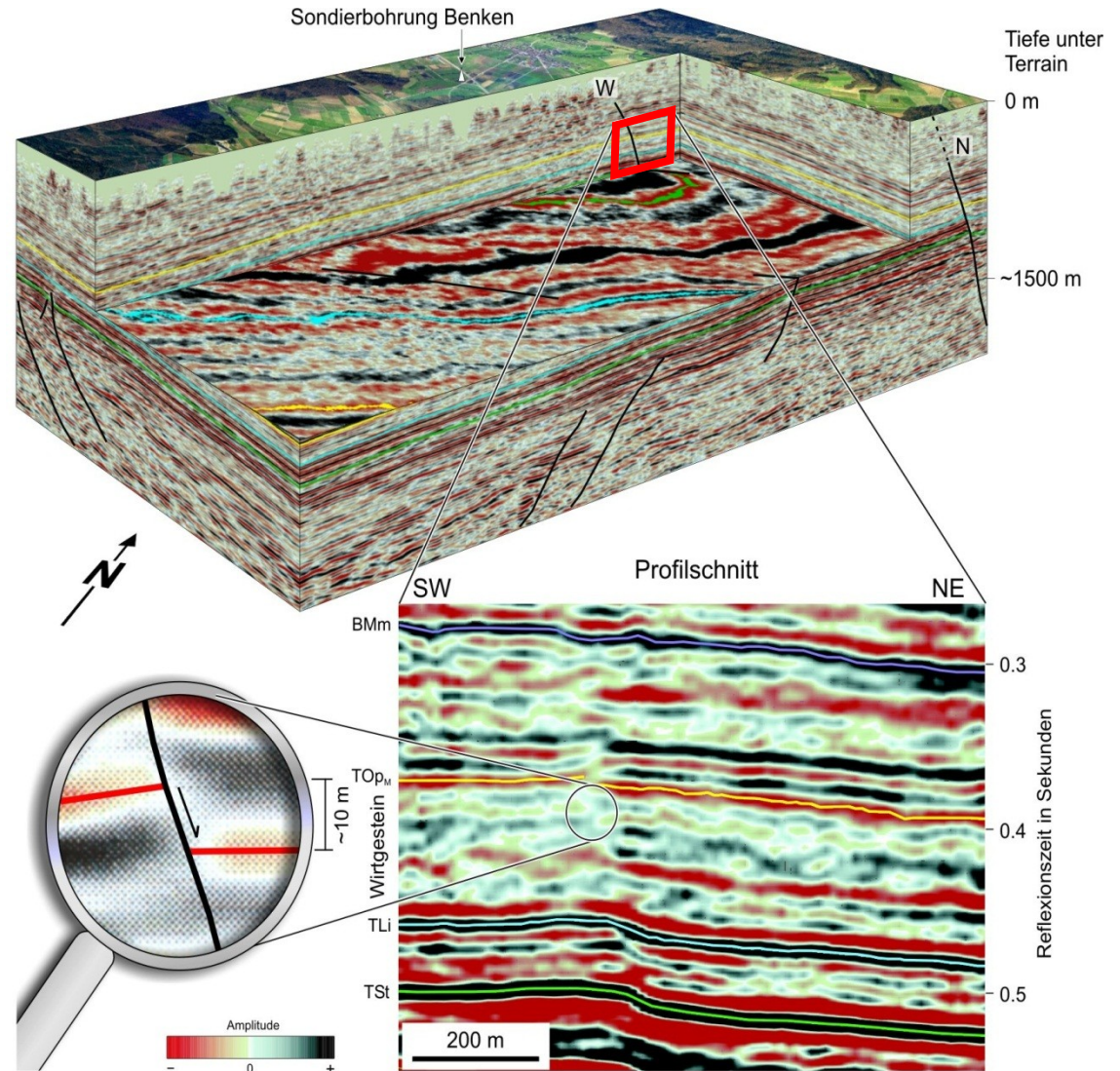


Borehole Benken, 2-D and 3-D seismics



3D - Seismics: Resolution

- Displacements > 10 m are directly visible
- Displacements can be clearly located
- **Geometry of rock layers and structures known**



Site selection process – The Sectoral Plan



Selection of potential siting regions for L/ILW & HLW

Criteria: safety, technical feasibility, preliminary evaluation of spatial planning issues

Stage 1

2008 - 2011



Selection of at least two sites for L/ILW and HLW

Criteria: socio-economic, environment, preliminary safety assessment, overall evaluation

Stage 2

ca. 4 yrs



Site selection & general licence (L/ILW and HLW repositories)

Criteria: safety, detailed evaluation of socio-economic issues, EIA (stage 1), overall evaluation

Stage 3

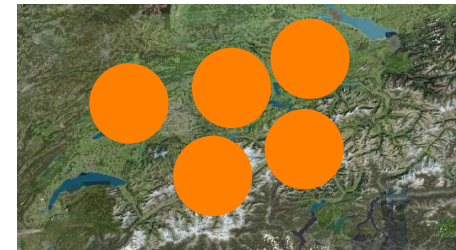
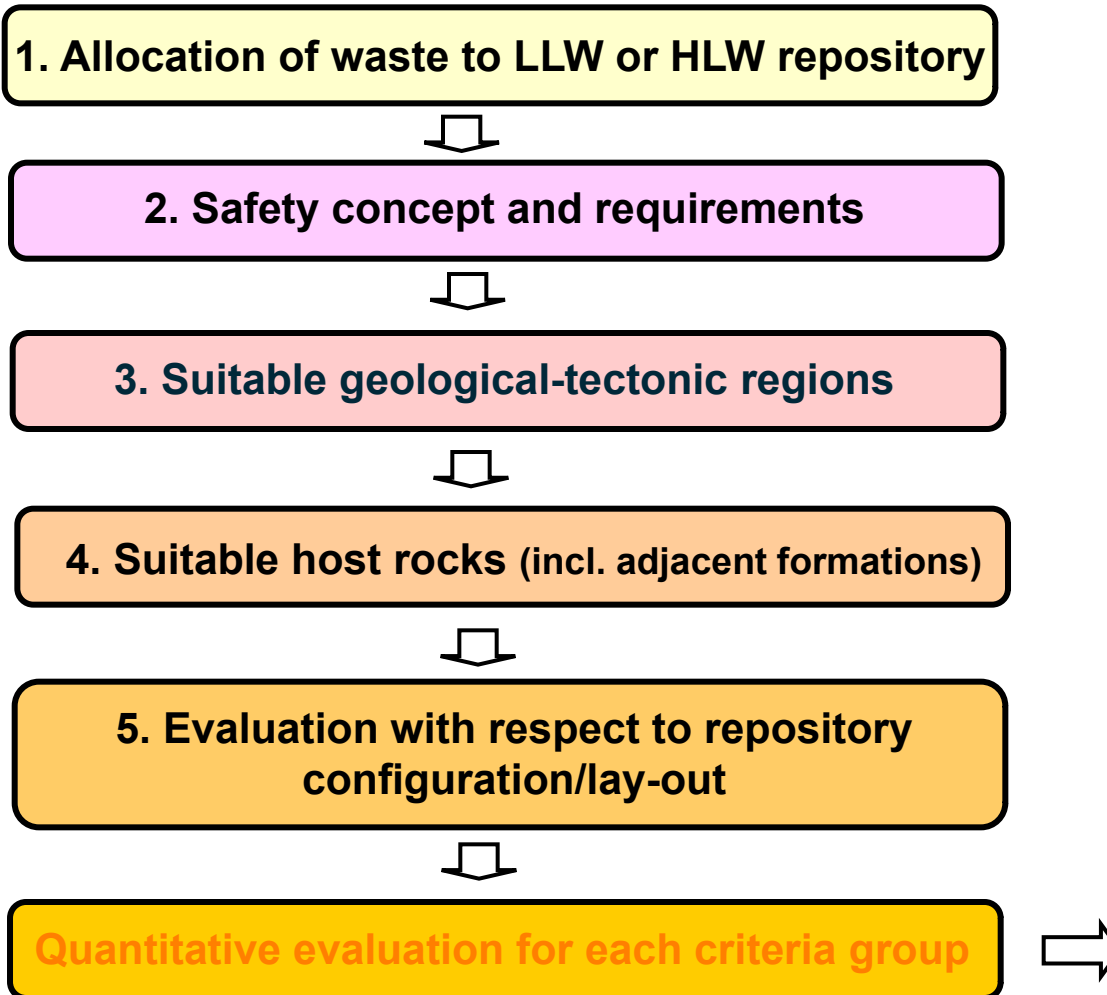
ca. 3.5 – 4.5 yrs



Source: Federal Office of Energy (SFOE)

Stage 1: Siting Regions

Methodology for 'Narrowing-Down' to the proposed siting regions


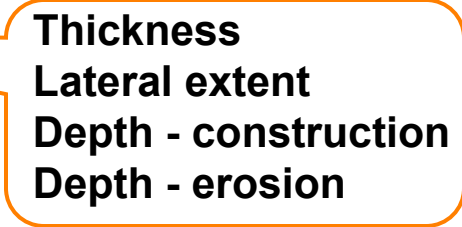



Safety & Engineering Criteria for Site Selection (1/3)

Group of criteria	Criteria
1. Properties of host rock	1.1 Spatial extent 1.2 Hydraulic barrier efficiency 1.3 Geochemical conditions 1.4 Migration paths
2. Long-term stability	2.1 Stability of properties 2.2 Erosion 2.3 Repository induced effects 2.4 Resource conflicts
3. Reliability of geological information	3.1 Characterisation of host rock 3.2 Spatial explorability 3.3 Temporal predictability
4. Suitability for construction	4.1 Rock mechanical properties 4.2 Underground access


Source: Bundesamt für Energie (BFE)

Safety & Engineering Criteria for Site Selection (2/3)

Group of criteria	Criteria 	Indicators (example)
1. Properties of host rock	1.1 Spatial extent 1.2 Hydraulic barrier efficiency 1.3 Geochemical conditions 1.4 Migration paths	 Thickness Lateral extent Depth - construction Depth - erosion
2. Long-term stability	2.1 Stability of properties 2.2 Erosion 2.3 Repository induced effects 2.4 Resource conflicts	
3. Reliability of geological information	3.1 Characterisation of host rock 3.2 Spatial explorability 3.3 Temporal predictability	 Regional fault model Continuity of formations Heterogeneity
4. Suitability for construction	4.1 Rock mechanical properties 4.2 Underground access	

Source: Nagra

Safety & Engineering Criteria for Site Selection (3/3)

	 Requirements
	> 100 m > 4 km² < 900 m.b.s. > 400 m.b.s

Source: Nagra

Multi-Attribute Analysis

		OPA						BD			EFF		HEL
		SMA-OPA-TJ-N	SMA-OPA-TJ-S	SMA-OPA-VZ-O	SMA-OPA-VZ-W	SMA-OPA-SJ-O	SMA-OPA-SJ-W	SMA-BD-TJ	SMA-BD-VZ-O	SMA-BD-VZ-W	SMA-EFF-SJ-O	SMA-EFF-SJ-W	SMA-MG-HEL
Gesamtbewertung sowie Kriteriengruppen und Kriterien (SGT Tab.1)													
Gesamtbewertung für bevorzugte Bereiche		P	P		P			P	P		P		P
1	Eigenschaften des WG/EG	●	●	●	●	●	●	●	●	●	●	●	●
1.1	Räumliche Ausdehnung	●	●	●	●	●	●	●	●	●	●	●	●
1.2	Hydraulische Barrierenwirkung	●	●	●	●	●	●	●	●	●	●	●	●
1.3	Geochemische Bedingungen	●	●	●	●	●	●	●	●	●	●	●	●
1.4	Freisetzungspfade	●	●	●	●	●	●	●	●	●	●	●	●
2	Langzeitstabilität	●	●	●	●	●	●	●	●	●	●	●	●
2.1	Beständigkeit der Standort- und Gesteinseigenschaften	●	●	●	●	●	●	●	●	●	●	●	●
2.2	Erosion	●	●	●	●	●	●	●	●	●	●	●	●
2.3	Lagerbedingte Einflüsse	●	●	●	●	●	●	●	●	●	●	●	●
2.4	Nutzungskonflikte	●	●	●	●	●	●	●	●	●	●	●	●
3	Zuverlässigkeit der geologischen Aussagen	●	●	●	●	●	●	●	●	●	●	●	●
3.1	Charakterisierbarkeit der Gesteine	●	●	●	●	●	●	●	●	●	●	●	●
3.2	Explorierbarkeit der räumlichen Verhältnisse	●	●	●	●	●	●	●	●	●	●	●	●
3.3	Prognostizierbarkeit der Langzeitveränderungen	●	●	●	●	●	●	●	●	●	●	●	●
4	Bautechnische Eignung	●	●	●	●	●	●	●	●	●	●	●	●
4.1	Felsmechanische Eigenschaften und Bedingungen	●	●	●	●	●	●	●	●	●	●	●	●
4.2	Untertägige Erschließung und Wasserhaltung	●	●	●	●	●	●	●	●	●	●	●	●

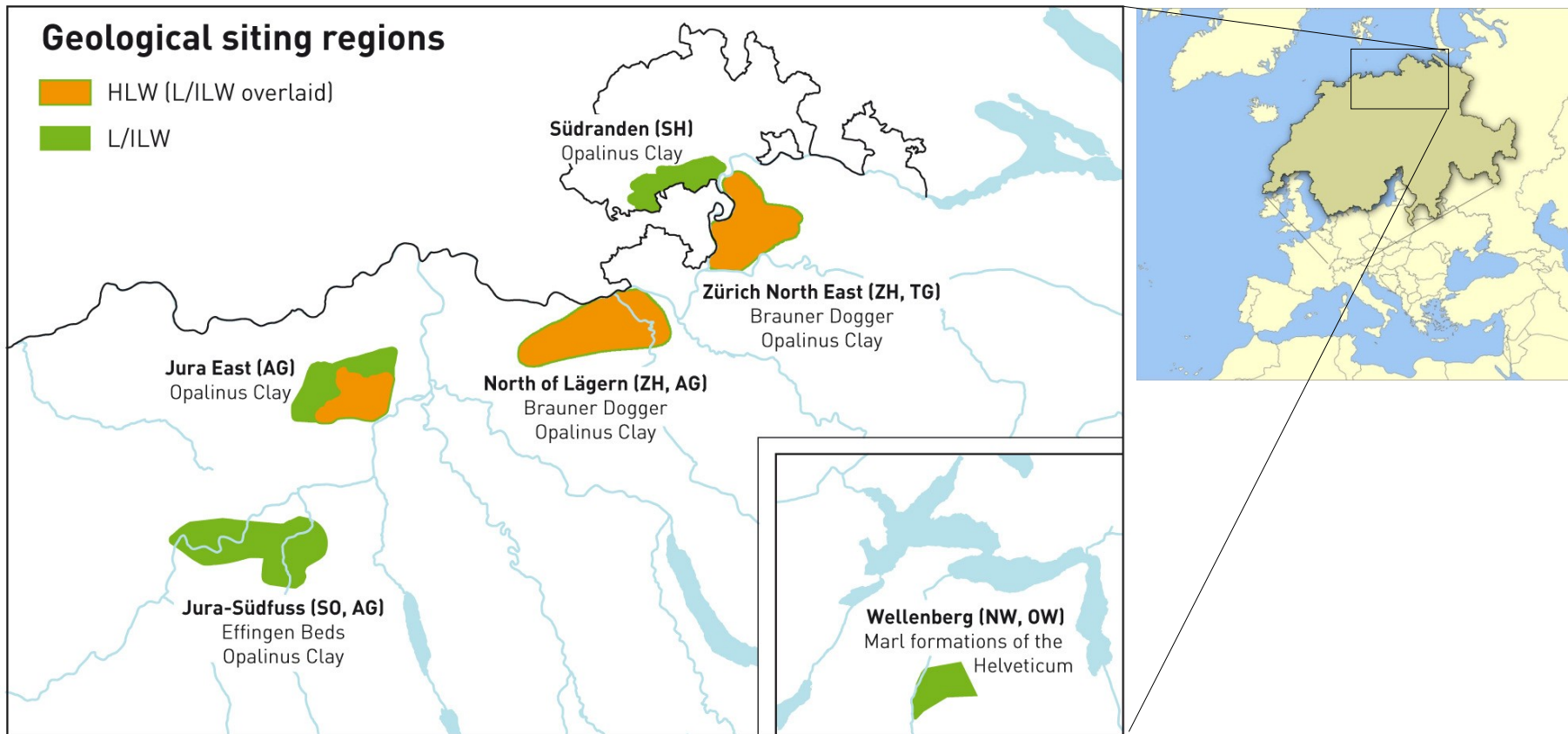
LLW
←

HLW
→

P priority area
 ● very favourable
 ● favourable
 ● less favourable
 ● unfavourable
 ● insufficient

		OPA			
		HAA-OPA-TJ	HAA-OPA-VZ-O	HAA-OPA-VZ-M	HAA-OPA-VZ-W
Gesamtbewertung sowie Kriteriengruppen und Kriterien (SGT Tab.1)					
Gesamtbewertung für bevorzugte Bereiche		P	P		P
1	Eigenschaften des WG/EG	●	●	●	●
1.1	Räumliche Ausdehnung	●	●	●	●
1.2	Hydraulische Barrierenwirkung	●	●	●	●
1.3	Geochemische Bedingungen	●	●	●	●
1.4	Freisetzungspfade	●	●	●	●
2	Langzeitstabilität	●	●	●	●
2.1	Beständigkeit der Standort- und Gesteinseigenschaften	●	●	●	●
2.2	Erosion	●	●	●	●
2.3	Lagerbedingte Einflüsse	●	●	●	●
2.4	Nutzungskonflikte	●	●	●	●
3	Zuverlässigkeit der geologischen Aussagen	●	●	●	●
3.1	Charakterisierbarkeit der Gesteine	●	●	●	●
3.2	Explorierbarkeit der räumlichen Verhältnisse	●	●	●	●
3.3	Prognostizierbarkeit der Langzeitveränderungen	●	●	●	●
4	Bautechnische Eignung	●	●	●	●
4.1	Felsmechanische Eigenschaften und Bedingungen	●	●	●	●
4.2	Untertägige Erschließung und Wasserhaltung	●	●	●	●

Proposed siting regions – geology



- A result of systematic application of requirements of Sectoral Plan
- Considered the geological possibilities of the whole of Switzerland
- Derived in a systematic, step-wise narrowing-in process based on safety and engineering feasibility

Narrowing down to the 20 sites (proposed in January 2012)

Goals/Requirements

Criteria

Ensure operational safety and feasibility

- Access/Connection to existing transportation network
- Topographical and geological situation
- Access to underground (repository)
- Operational safety

Guarantee compatibility with land use and environment

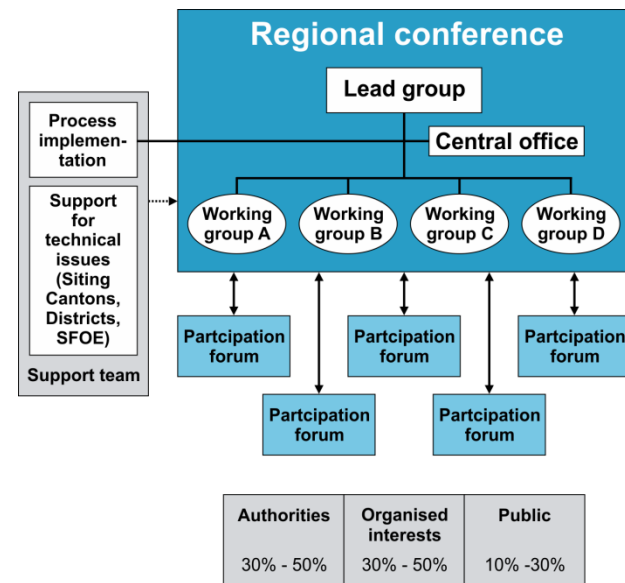
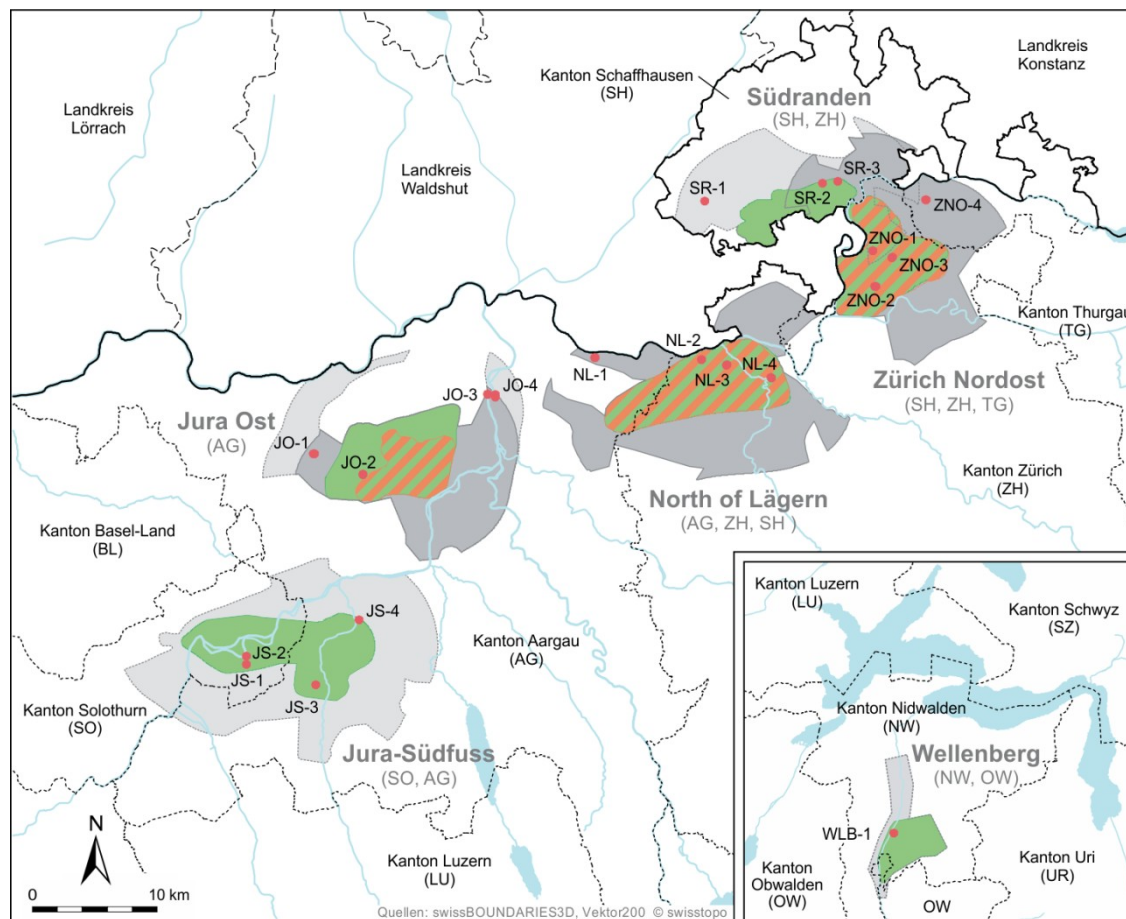
- Zonation
- Surface water bodies
- Grundwasser
- Mineral water wells /hot springs
- Protection of nature and landscape

Appropriate local integration in the region

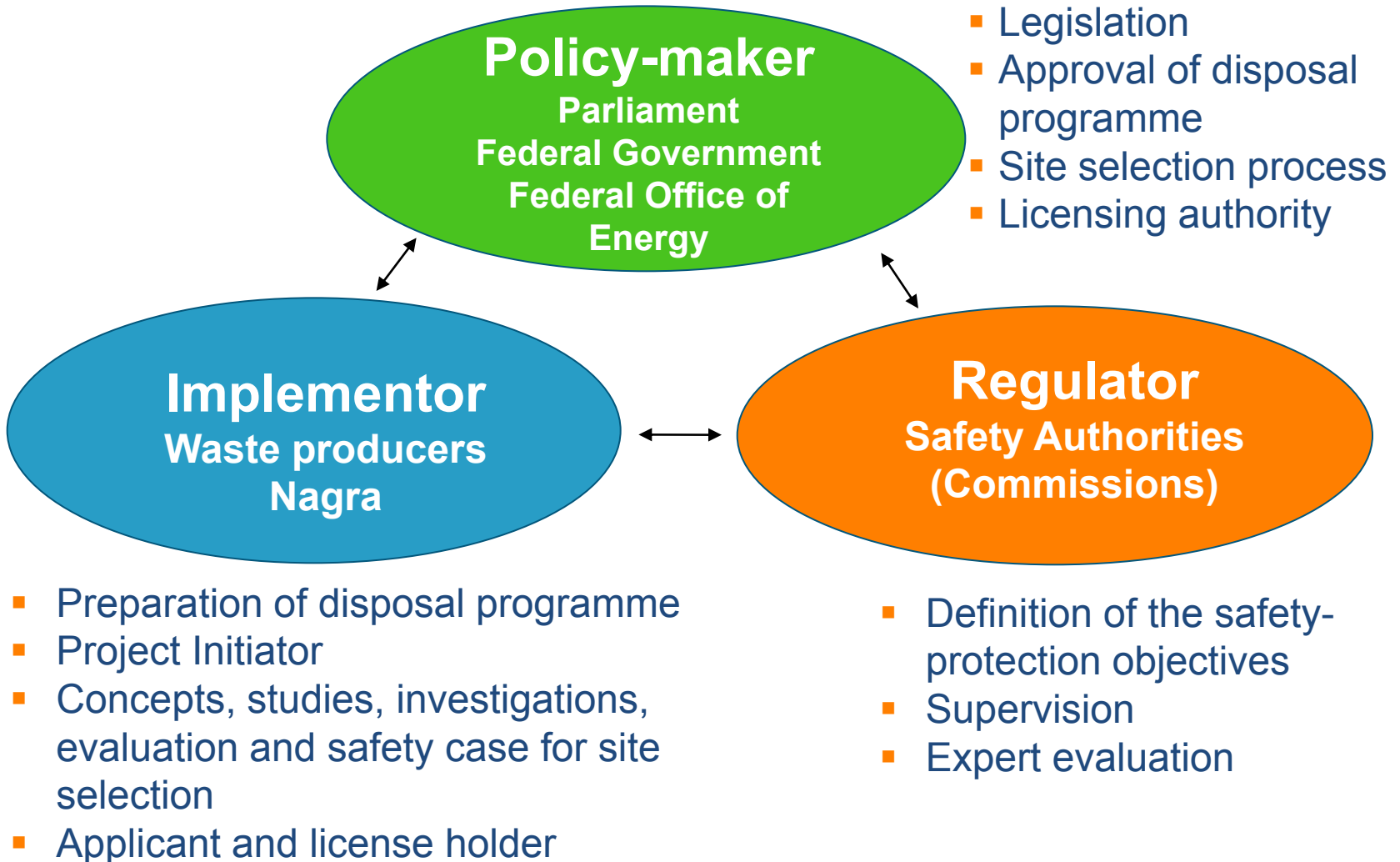
- Current use
- Embedment in urban development and landscape
- Recreational infrastructure/usage
- Landscape and natural scenery

Stage 2: Selection of sites for the surface facilities

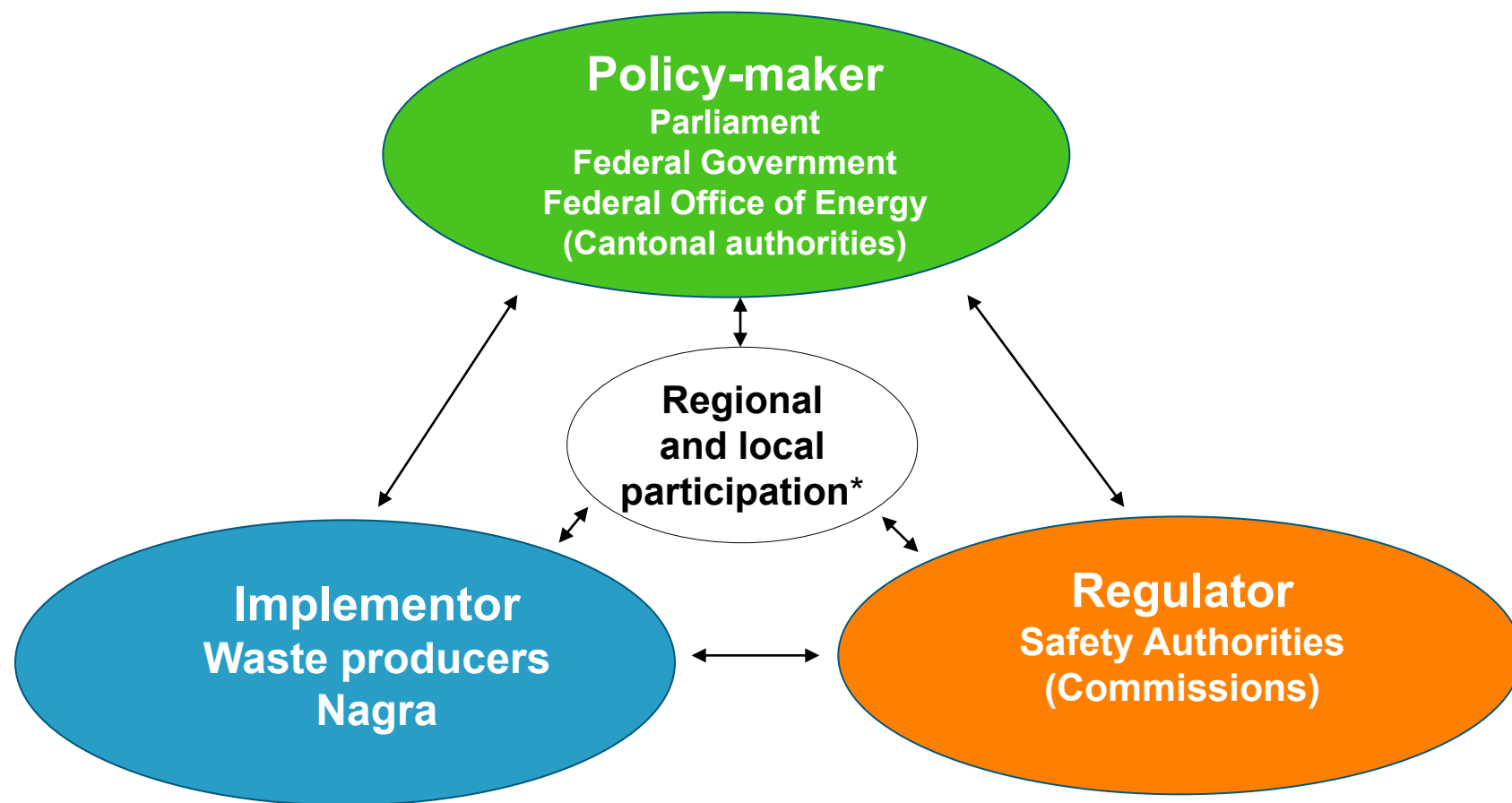
Discussion of proposals within regional conferences



Roles and Responsibilities in Switzerland



Roles and Responsibilities in Switzerland



*Emphasis on socio-economical and environmental issues; location of surface facilities; representation of regional and local interests

Swiss Site Selection Approach: Key strengths

1. Nomination with respect to the host rock and the siting regions, on the basis of safety and engineering criteria defined explicitly and in advance; strong participatory component for the surface facilities and their location
2. Clear roles and responsibilities
3. Leadership by the Swiss Federal Office of Energy
4. Step-wise decision making and step-wise approval
5. Recognised and accepted technical and scientific know-how from the implementer and the regulator
6. Transparent and traceable decision making (also recognised by the authorities in their review)